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Increasing Child Immunization Through Uninterrupted Power

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Increasing Child Immunization Through Uninterrupted Power

Abstract

We study the effect of a unique electrification upgradation program, Jyotigram Yojana (JGY), in India on child vaccination rate. We match precise JGY rollout data with the third wave of the Reproductive and Child Health Survey (DLHS-III). We find that higher program exposure, measured by percentage of villages that implemented the JGY program in a district, leads to higher probability of receiving a wide range of basic child vaccines. An examination of underlying mechanisms indicates that electrification upgradation program increases vaccination rate by improving health service delivery at local primary healthcare facilities and improving access to health related information through television.

1 Introduction

Across the developing world, there is a strong emphasis on the need for basic infrastructure, in particular, electrification. Construction and expansion of infrastructure is viewed as critical for growth and poverty alleviation (Ali and Pernia (2003)). Electrification is considered especially important for rural households as it has both direct and indirect impacts on income and productivity, children's education, security, and environment (Khandker et al. (2013)). Much of the earlier literature on development effects of rural electrification finds that rural electrification leads to higher income and consumption, better schooling outcomes for children, lower poverty, increase in female labor supply, and reduction in fertility (Dinkelman (2011); Peters and Vance (2011); Khandker et al. (2013); Lipscomb et al. (2013); van de Walle et al. (2013)).

In addition to income and employment, the development gains of electrification also lie in its impact on human capital building. Two main components of human capital are education and health. Past literature has found significant effect of electrification on education, but the evidence on health is limited and mixed (Lipscomb et al. (2013); van de Walle et al. (2013)). Using data from Brazilian counties, Lipscomb et al. (2013) find no effect of electrification on longevity or infant mortality. They argue that electrification brings better health care technology and service delivery but also leads to expansion of more hazardous sectors such as manufacturing. Using electricity blackout as a negative shock, Burlando (2014b) finds that in Tanzania prolonged lack of electricity has a negative effect on child birthweight due to transitory income shocks.

In order to better understand the link between electrification and health, this paper studies the effect of an electricity infrastructure upgradation program in India on the consumption of one of the most primary medical goods provided by the government: child vaccination. Childhood health has a long lasting effect on human capital accumulation throughout one's course of life (Case et al. (2002); Currie and Stabile (2003)). The link between childhood and adult health is particularly enduring in developing countries due to the lack of mitigation strategies such as a well-functioning healthcare system and public health support (Currie and Vogl (2013)). Child vaccination is the most effective way to reduce mortality associated with preventable diseases in developing countries. It not only reduces disease morbidity among infants and adults but also promotes better physical and cognitive growth among children (Koening et al. (1990); Kristensen et al. (2000); Lu et al. (2006); BenYishay and Kranker (2015)).

Even with the implementation of the Expanded Program on Immunization (EPI), many developing countries continue to face the issue of inadequate vaccine coverage leading to nearly 2 million children dying from preventable diseases every year (WHO (2008)). India, for example, has seen only a marginal improvement in full immunization of 5% between 2005 and 2009. Some states continue to experience high or even increasing immunization dropout rate, including the area of our study Gujarat UNICEF (2010).[1] Figure (2) shows the trend of vaccination in India over the past decade and for all of the basic vaccines the coverage rates have greatly fluctuated and fallen in recent years.

It is argued that vaccination rates can be increased through both demand-side incentives and supply-side improvements (Banerjee et al. (2010)). Previous literature has largely focused on demand-side incentives. One strand finds that financial incentives via conditional cash transfers can effectively increase the vaccination rate in some developing countries (Morris et al. (2004); Barham and Maluccio (2009)). However, the effect sizes are small for countries that have already achieved a relatively high baseline immunization rate (Lagarde et al. (2007); Fernald et al. (2008)). Other studies find that large information campaigns and education is more effective in driving up demand of such preventive care (BenYishay and Kranker (2015)). On the supply side, using evidence from a randomized control trial, Banerjee et al. (2010) show that interventions that combine small financial incentives for households with improved reliability of healthcare services are more effective than providing incentives alone.[2] So far no attempt has been made to study the effects of large-scale supply-side interventions such as reliable infrastructure on immunization rates.

We study the effect of an electrification upgradation program, Jyoti-

[1] Full immunization refers to completing the full schedule of recommended vaccines.

[2] Banerjee et al. (2010) argue that reliable health service is achieved by having medical staff show up at the village immunization camp on a fixed date and time in a month.

gram Yojana (JGY), launched in October 2003 by the state government of Gujarat, on child immunization rate. The program provides 24-hour high quality electricity for non-agricultural consumers in rural areas. It uses an innovative feeder segregation strategy that rations the agricultural use of electricity to a pre-scheduled eight hours of uninterrupted, high quality three-phase electricity and guarantees 24-hour three-phase electricity supply for rural households, schools, hospitals (including primary healthcare facilities and centers) and small commercial users.[3] Using detailed village-level program rollout data between 2003 and 2008, we match the program implementation with the third wave of Reproductive and Child Health Survey (DLHS-III) conducted in 2007-2008. Exploiting the variation in program rollout at the timing of birth, we investigate the effect of the rural electrification program on childhood immunization rate. We find that higher proportion of JGY villages in the district of residence improves immunization rate for BCG and Hepatitis B for the full sample. For children 36 months and older at time of interview, it also leads to improved immunization rate for DPT, polio, and measles in addition to BCG and Hepatitis B. We explore potential channels through which improved rural electrification affects immunization using the same dataset. We find that JGY significantly increases service quality at local primary healthcare facilities. It also increases health information accessed through television. These findings are consistent with predictions derived from our conceptual framework.

This paper adds to the ongoing discussion on the effect of electrification on human capital building in developing countries. Our findings confirm the positive causal effect of electrification on health services received during childhood such as basic immunization. This paper also brings to the fore the mechanisms through which electrification improves health service delivery by exploiting the richness of health indicators and facility data in the DLHS surveys. These findings shed light on the non-monetary effects of electrification programs and contribute to the debate in the develop-

[3]In India, single-phase electricity is a 230V supply typically provided through two wires and three-phase electricity is 415V supply typically provided through four wires. The three-phase supply can be stepped down to provide several 230V power outlets in individual dwellings or units. Three-phase power supply is superior to single-phase supply as it can support heavy loads such as those required for farm equipment.

ment literature on large infrastructure programs versus other alternatives. As pointed out by the World Bank, making electricity available to rural households is not sufficient to increase their welfare if not supported by efforts to improve its reliability (Andres et al. (2013)). Much of the earlier literature on development effects of rural electrification looks at the impact of mere access to electricity and not the reliability or quality of supply. Our study evaluate the effects of an infrastructure upgradation program and, to our knowledge, is the first paper to provide evidence on the effects of 'quality' of electricity supply.

Our results underscore an important determinant of consumption of preventive care: quality and reliability of healthcare services. As most vaccines are free of charge, opportunity cost of time becomes critical in consumers' decision process. Time cost for vaccination is closely related to quality and reliability of healthcare service at these local healthcare facilities. Productivity of working staff, lighting, operation capacities, and queuing time are all important to determining the overall time taken for getting a child vaccinated (Banerjee et al. (2004)). Our analysis adds to the literature by showing that an increase in operational capacity of health clinics as a result of electrification can lead to an increase in immunization rate.

2 Policy background on Jyotigram Yojana

Prior to the implementation of Jyotigram Yojana (JGY), Gujarat already had basic electricity infrastructure in place. About 89 percent households in the state had electricity and were able to run basic household devices such as an electric lamp.[4] The challenge for the Gujarat State Electricity Board (GEB), which was the main power utility, was to balance the electricity needs of the agricultural and non-agricultural users. Before 2003, a single feeder was used to supply three-phase electricity to agricultural, domestic, and small commercial users in rural areas. Farmers were given priority and provided highly subsidized farm connections. This was un-

[4] Authors' calculation using 2002 National Sample Survey (NSSO) data

sustainable for GEB as farmers over-exploited subsidized electricity to run water extraction mechanisms (WEMs) and tariff collection from these users was not enough to cover the production and transmission costs. Raising tariffs was politically unpopular and eventually GEB piled up a deficit of nearly USD 333 million in 2001. This forced GEB to reduce both the quantity and quality of electricity supply to rural areas. Three-phased power supply was reduced from 18-20 hours to 10-12 hours of irregular supply and for the remaining time there was intermittent supply of low quality single-phase electricity. Poor quality and quantity of electricity directly affected farmers and there was an increase in illegal usage, where farmers used capacitors to convert single-phase electricity to three-phase electricity to run their WEMs. This worsened the electricity access for domestic and small commercial users in rural areas (Shah et al. (2008); Chindarkar (2015)).

JGY, which translates as electrified or lighted village, was launched by the state government of Gujarat in 2003 with the aim of increasing the accessibility and reliability of the electricity grid in rural areas through segregation of agricultural and non-agricultural transmission lines. It did not cover urban areas and therefore did not alter the supply status in these areas. Under JGY, the state government segregated the agricultural and non-agricultural feeders for each village. Agricultural users are provided eight hours of uninterrupted, three-phase electricity as per a pre-decided time schedule, and domestic and small commercial users are provided 24-hour three-phase electricity. This includes households, schools, health centers, and small commercial users (see Figure (1)). Therefore, post-JGY there has been a significant change in the quantity and quality of electricity supply to rural areas. (Chindarkar (2015)).

The improvement in quality of supply is largely attributable to the technical design of JGY. To ensure minimum transmission losses, electricity is transmitted from the source (power plants) to end consumers in various steps. High voltage transmission is often used to transmit voltage over large distances; generally electricity is transmitted in the voltages of 132 kV, 220 kV, or 400 kV and depends on the distance of transmission. These lines typically have lengths of few hundred kilometres and feed the electricity into the grid. The voltage is then stepped down to a 33 kV or 66 kV at the substation-level which is again reduced to 11kV at the feeder-level. These 11 kV feeders transmit electricity to the end consumer points where a transformer would again step down the voltage to either 240V (for single-phase supply) or 415V (for three-phase supply). Often the length of 11 kV line in rural areas is up to 20 kilometers with smaller lines restricted to a distance of 0.5-1 kilometer from the transformer, since larger distances can lead to huge fluctuations in voltage (Kanpur (2014)).

Tariffs data indicate that household users only experienced marginal changes in tarrifs after 2007 and there is no change in tariffs for agricultural users up until 2010.[5] To raise funds for the implementation of JGY and make villages direct stakeholders in the implementation process, the state government initially proposed that villages contribute 30 percent of the feeder cost or INR 25,000, whichever was higher per village per feeder before actual feeder segregation could begin. It allowed villages to draw upon grants provided under other development schemes and also through local cooperatives and factories. However, soon realizing that waiting for funds collection was delaying the implementation process, the government decided to continue segregating the feeders and collect the funds in parallel (Chindarkar (2015)).

3 Immunization and vaccine cold chain in India

Immunization is known to be an effective measure against preventing childhood diseases, infant mortality, and disease-related disability (UNICEF (2010); Ministry of Health and Family Welfare (2010)). Effective administration of immunization however requires an institutionalized health and disease surveillance system, trained health professionals, and a cold chain to safely transport and store the vaccines.

The successful smallpox eradication campaign in India established the first such effective system. In 1977, India was declared smallpox-free and

[5]Please refer to online appendix for tariffs data.

the government launched the National Immunization Programme called the Expanded Programme of Immunization (EPI) in 1978 leveraging the success it had achieved with smallpox. The main objective of EPI was to reduce mortality and morbidity related to vaccine preventable diseases (VPDs). In 1978, the schedule included BCG, OPV, DPT, and typhoid-paratyphoid vaccines.

In 1985, EPI was further expanded and renamed as Universal Immunization Programme (UIP) to increase the coverage of immunization. The revised schedule included the measles vaccine and tetanus toxoid vaccine for pregnant women but dropped the typhoid-paratyphoid for children due to its low efficacy and the perception that there was reduced disease burden from typhoid. In addition to expanding the immunization schedule, the objectives of UIP also included improving quality of health services and establishing a reliable cold chain that covered the last mile, that is, till the primary health center and sub-center levels (Lahariya (2014)). In 1990, Vitamin A was added to the immunization schedule owing to the high incidence of Vitamin A deficiency-related blindness (Kapil and Sachdev (2013)). The Hepatitis B vaccine was recommended by World Health Organization in its fourteenth Global Advisory Group meeting on the EPI in 1991. However, it was formally included in the UIP immunization schedule starting in 2007 in 10 states (not including Gujarat) and expanded to the entire country in 2011 (Ministry of Health and Family Welfare (2011)). In 1995, the Government of India launched the Pulse Polio Immunization (PPI) campaign as part of the global effort to eradicate poliomyelitis (commonly known as 'polio').

In rural India, vaccines are usually administered at the primary healthcare centers (PHCs), which are government-funded clinics and are manned by at least one medical officer, paramedics, and other staff. The vaccines are provided free of charge at PHCs and other government clinics (Datar et al. (2007)).[6] The average vaccination coverage rate in India for critical

[6]Rural households may also access other government health facilities such as subcenters (SCs), which are one level below PHCs and are typically single-room facilities manned by an auxiliary nurse midwife (ANM) or community healthcare centers (CHCs), which are one level above PHCs and are staffed by specialists such as surgeons, paediatricians, and gynaecologists. Rural health infrastructure is primarily provided by the government and private provision is limited (Datar et al. (2007)).

vaccines such as Polio3, DPT3, BCG, and measles between 2003 and 2008 (our period of study) has been in the range of 80-90% (see Figure (2)).

Both vaccine safety and potency are affected if they are not transported and stored at recommended temperatures. The WHO and MHFW recommend that all vaccines except OPV be stored at 2 to 8 degree Celsius as vaccines are both heat and freeze sensitive. The recommended temperature for OPV is -15 to -25 degree Celsius. The cold chain in India is long and any breakdowns could damage the vaccines permanently making them unusable and unsafe to administer (Ministry of Health and Family Welfare (2010)). Figure (A.1) in online appendix represents the vaccine cold chain in India. As shown, it is crucial that the vaccine cold chain at the lower levels (district, PHCs, and SCs) links up with the higher order chain. To be effective, the following cold chain equipment must be available and properly maintained – refrigerator/freezer, thermometer, cold box, ice-lined refrigerators, and vaccine carriers (Ministry of Health and Family Welfare (2005)). Stable electricity supply is essential for the proper functioning of refrigerators/freezers, cold boxes (as the temperature inside is maintained using ice packs), ice-lined refrigerators, and vaccine carriers (as they also need to be lined with ice packs). In case of a power failure, it is recommended that health workers at PHCs and SCs immediately record the temperature that vaccines have been exposed to. If the duration of the power failure is known and the temperature inside the storage equipments remains below 8 degree Celsius, the vaccines may be continued to be used. However, in case of prolonged power failure or unknown durations of power breakdowns, it is recommended that vaccines be immediately transported to another place for safe storage (Ministry of Health and Family Welfare (2005)). Availability of stable electricity supply is therefore crucial in safely storing and preventing wastage of vaccines.

4 Conceptual framework

In rural India, all government recommended vaccines are provided free of charge at local PHCs. However, based on government documents and national surveys, a significant share of children still fail to be fully immunized. In the DLHS-III survey, a mother would be prompted to explain the reasons if her child did not receive proper vaccination. Summary statistics for this question are reported in Table (1). Among the 655 children that did not receive any vaccination, the most cited reason is "child too young", which is reported by 37.6% of the mothers[7], followed by "lack of information" (35.6%), "mother too busy" (17%), too far (9.5%), time inconvenient or waiting time too long (7.8%) and financial problem (1.1%). The reported reasons can be classified into two broad categories: lack of proper knowledge and time constraint.

Motivated by these descriptive statistics, we discuss the theoretical underpinnings of the JGY program on child immunization in this section. The JGY program provides 24 hour three-phase electricity to both rural households and facilities, including PHCs that provide vaccination services. Therefore, both supply and demand for vaccinations will be influenced by the program.

For rural households, home production is an important aspect for the household optimization problem. Following the home production model discussed in (Gronau (1986)), we assume a household maximizes its utility $U = U(Z_0, Z_1 ... Z_m)$, where Z_i is the ith commdity (or activity). The production function takes market good X_i and time T_i as inputs with form $Z_i = f_i(X_i, T_i)$. The household is endowed with T units of time and the full budget constraint is $\sum_{i=0}^{m} P_i X_i = w(T - \sum_{i=0}^{m} T_i) + V$, where V is the non-labor income and P_i is the price of market good X_i. A necessary condition for maximizing utility U is $\frac{\partial U}{\partial Z_i} = \lambda(P_i x_i + w t_i)$, where λ is the marginal utility of income and x_i and t_i are marginal inputs of goods and time in the production of Z_i.[8] If child vaccine is provided free of charge, then the condition becomes $\frac{\partial U}{\partial Z_i} = \lambda w t_i$.

The electrification program therefore has two effects on the equilibrium consumption of vaccination. On the household demand side, the program has an endowment effect on T as it would probably make the days longer. The endowment effect increases household income and hence holding ev-

[7]As many of the vaccines in the DLHS-III survey, including Polio-1, Hepatitis B, and BCG need to be administered at birth or few weeks after birth, this answer also reflects the lack of proper knowledge.

[8]The marginal inputs for each activity Z_i are defined as: $x_i = \frac{\partial Z_i}{\partial X_i}$;$t_i = \frac{\partial Z_i}{\partial T_i}$

erything else unchanged, the income effect leads to higher demand for any normal good including child vaccine. Depending on effect of electrification on various household activities, household will also substitute towards more labor intensive activities as discussed in Dinkelman (2011). Second, if the electrification program generates positive supply side shocks by providing more reliable service, such as better lighting and vaccine storage equipment, it will effectively reduce the marginal inputs of time for immunization t_i. Holding everything else unchanged, the supply side shock will also lead to increase in equilibrium consumption of vaccination as it reduces $\lambda w t_i$.

Aside from price and income effect, electrification might lead to increased demand for vaccination through improved allocative efficiency of health production. Using definitions in (Grossman (2006)), improved allocative efficiency means as access to electricity increases, households would pick a different mix of medical goods. One possible channel for this to happen is through access to television programs. For example, government campaigns on child immunization would have a better chance of reaching rural households if they own a television and have steady electricity supply. Information embedded in soap operas, talk shows, and news could also have an impact on households' perception on importance of child immunization.[9]

In summary, we expect to see a positive relationship between quality of electricity and child immunization rate. The effect comes from four potential channels: (a) the income effect, (b) substitution effect among different household commodities(activities), (c) supply side effect, and (d) information. To test the mechanisms, we need (i) household time use data (ii) PHCs service quality data and (iii) television viewing patterns in order to study the channels through which electrification affects the equilibrium consumption of child immunization. Unfortunately, the DLHS-III does not have abundant information on household production and time use. Therefore, we use employment data from three waves of National Sample Survey (NSS) to provide supporting evidence for channels (a) and (b).

[9]Several studies have examined the impact of media programs that contains information on desirable health behaviors. Studies by (Vaughan and Rogers (2000);Vaughan et al. (2000);Vaughan et al. (2000)) documents the effect of media on knowledge, attitudes, and behaviors towards HIV.

DLHS data are used to test channels (c) and (d).

5 Data and empirical strategy

5.1 Data

Data for this paper primarily come from two sources - JGY program rollout data obtained from the electricity distribution companies and health and facility data obtained from the third wave of Reproductive and Child Health Survey (DLHS-III). Village-level JGY rollout data were obtained through administrative records provided by the four regional distribution companies in the state of Gujarat. These companies together cover all districts of the state of Gujarat. The administrative data record the exact timing (year-month) when JGY was implemented in each village in the state of Gujarat. For each month during the program rollout period, we compute the percentage of villages within a district that have been covered under JGY.[10] Figure (3) plots the cumulative distribution of program rollout for each district. As shown in these graphs, the start dates and completion dates of JGY implementation vary across districts. The earliest start date of JGY implementation is July 2003 and latest completion date is March 2008. This suggests that the speed of program implementation is different across districts so that in any given month between July 2003 to March 2008, there is significant heterogeneity in the percentage of villages electrified across the twenty-five districts.

DLHS surveys are nationally representative household surveys conducted by the Government of India since 1998. In this paper we use the third wave of DLHS conducted in 2007-2008. DLHS-III follows a two-stage stratified sampling method in rural areas and three-stage stratified sampling method in urban areas. It covers all census districts and is therefore representative at the district-level.

All DLHS-III households in Gujarat were interviewed in 2008. In total we have 26,145 households in our final sample from the 25 districts in Gujarat, among which 18,865 are rural households and 7,280 are ur-

[10]The administrative divisions of India are nested and hierarchical as follows (largest to smallest) - states and union territories, districts, sub-districts (talukas or tehsils), blocks, and villages.

ban. The main survey instrument for DLHS-III comprises of three sets of individual/household questionnaires: household, ever married woman, and unmarried woman. It also includes village questionnaires and health facility questionnaires (PHCs, CHCs, SCs, and district hospitals) in the integrated facility survey. Our analysis is based on a dataset of 17,919 eligible women from rural areas in Gujarat.

5.2 Identification strategy

To study the impact of JGY, we exploit the variation in district-level program exposure at the time when a child was born. For each living child born after January 1, 2004 in the DLHS-III survey, we match the year-month of birth with the year-month of district-level cumulative program implementation. Therefore, for each child, we are able to compute the exact cumulative percentage of villages electrified in its district at the time of birth. We hereafter refer to this percentage as the program exposure.[11] From the household's perspective we can interpret program exposure as the probability that it would be exposed to the JGY program at the time of interview. We employ an intention-to-treat framework and consider all households in the district to have the same program exposure at a given time.

The cross-district variation in exposure to JGY is determined by two factors: the starting date of JGY and the speed of implementation. Previous literature argues that expansion of electricity networks and other large infrastructure is often planned and systematic and therefore suffers from program placement bias. These studies find that infrastructure placement and speed of infrastructure construction is correlated with geographical characteristics such as land gradient (Dinkelman (2011); Duflo and Pande (2007); Lipscomb et al. (2013)). As Gujarat is topographically a very flat state, we do not find land gradient to be a significant determinant of program expansion.[12] Using village-level average land gradient as the independent variable and probability of JGY being implemented as the dependent variable, we do not find the coefficient of land gradient to be significant.

[11] Due to privacy protection policy of the DLHS surveys, village names are encrypted and we are unable to match the program rollout data at the village-level.

[12] The average land gradient of Gujarat is 1.88 degrees with a standard deviation of 1.85 degrees.

However, if we regress the percentage of villages electrified under JGY on land gradient and district size, we find district size to capture most of the variation in program implementation.[13] Our finding could be linked to the nature of the JGY program. To reiterate, JGY was an electrification upgradation program. It did not involve construction of new power stations but rather involved rewiring at the sub-station and feeder-level. As explained in Section 2, the 11 kV feeder lines in rural areas typically have lengths upto 20 kilometers with smaller lines connecting to the households restricted to a distance of 0.5-1 kilometer from the separator to avoid large voltage fluctuations. Therefore, our evidence leads us to believe that the speed of JGY implementation is mainly driven by the size of the district.

As previously discussed, starting the feeder segregation process initially required villages to contribute a certain sum. However, as it was stalling the implementation process, this requirement was relaxed and the feeder segregation and funds collection continued in parallel. It is still likely though that the starting date of JGY, as well as implementation speed could be correlated with district-level socio-economic characteristics. Unobserved district-level heterogeneities that correlate with both program rollout and vaccination status of a child could potentially bias a simple OLS estimate. We address the potential endogeneity of program rollout using a fixed effects model explained in the next section.

6 JGY and child immunization

6.1 Empirical specification

To estimate the effect of JGY on child immunization, we match the JGY rollout data with DLHS-III conducted in 2007-2008. The survey contains detailed pregnancy history since January 1, 2004 for ever-married women (aged 15-49), and every woman was asked to provide detailed information on vaccination for the last two births that were born since January 1, 2004 and were alive at the time of interview. Other health investments such prenatal and postnatal check-ups are provided by the respondent for the last pregnancy that ended in live birth or stillbirth since January 1, 2004. We include all children under the age of five (60 months) at the time of

[13]Results available upon request.

interview. Our final sample consists of 7,491 children born between 2004-2008. Due to the fact that mothers interviewed were only required to report the vaccination status of children who survived till the time of interview, all the children who died before the interview are excluded. Each child is matched with JGY rollout data by the month and year of birth. As the JGY program was launched in July 2003, all children in this dataset were exposed to the program, but the level of program exposure depends on the time and district of birth. We estimate the effect of program exposure on vaccination status with the following specifications

$$y_{idt} = \alpha_0 + \alpha_1(Exposure_{idt-1}) + \Pi' X_i + \varphi(D_d) + \gamma(C_t) + \phi(D_d \cdot t) + \epsilon_{idt}, \quad (1)$$

and

$$y_{idt} = \alpha_0 + \alpha_1(\frac{1}{12}\sum_{s=0}^{11} Exposure_{idt+s}) + \Pi' X_i + \varphi(D_d) + \gamma(C_t) + \phi(D_d \cdot t) + \epsilon_{idt}, \quad (2)$$

where y_{idt} denotes the vaccination status for child i born in district d in year-month t. y_{idt} is a binary outcome variable that takes value 1 if a child received a certain vaccine and 0 otherwise. We report results for all vaccinations as recommended by the Indian Academy of Pediatrics (IAP) and the Ministry of Health and Family Welfare (MHFW) by appropriate age and timing of vaccination. Table (2) lists all the vaccines. We use two measures to capture program exposure. The first measure is $Exposure_{idt-1}$, calculated as the proportion of villages covered by JGY in district d and year-month $t-1$, that is, the month preceding the child's birth month. The second measure $\frac{1}{12}\sum_{s=0}^{11} Exposure_{idt+s}$, which is the average exposure during the first year after a child was born. It is the average of the proportions of villages covered by JGY in district d from year-month t to year-month $t+11$. Both measures take values between 0 and 1 and represent proportions. X_i is a set of demographic controls observed at the time of interview, including a vector of dummies indicating child's birth order, an indicator of single or multiple birth, mother's age at the time of child's birth and its quadratic form, both parents' education levels in years, household size, religion and caste of head of household, age and gender of head of household, and household's wealth index.

As discussed in section (5.2), there are two sources of variation for variable $Exposure_{idt}$: JGY starting date and the speed of implementation. These two sources of variation indicate the following potential issues of endogeneity: (a) unobserved district characteristics and birth month effects that correlate with both program exposure and child immunization status, and (b) unobserved district characteristics that correlate with the difference in speed of implementation and changes in vaccination status. An example of this would be a sudden growth in district budget that boosts up the implementation speed as well as child immunization rate. We address the first two sources of endogeneity by including district fixed effect D_d and birth year-month fixed effect C_t. We address the second source of endogeneity by controlling for district time trend ($D_d \times t$). In doing so, we not only control for differences across districts and over birth year-month in mean vaccination status, but also for the differences in change in mean vaccination status across districts over time. For simplicity of interpretation, α_1 is estimated using linear probability model throughout the paper, unless noted otherwise.[14]

Table (3) presents the summary statistics of the data constructed from DLHS-III. We report the mean and standard deviation of each vaccine by four age groups: 0-11 months, 12-23 months, 24-35 months, and 36 months above. We also report the average JGY coverage at birth and during first year of birth by age group. Consistent with past literature, we find significant dropout rate for DPT and Polio (UNICEF (2010)). The vaccination rate for Hepatitis and Vitamin A remains low even for the oldest age group and the full vaccination rate is only around 25%.

6.2 Results

Table (5) reports the effects of JGY exposure at birth on children's vaccination estimated by equation (1). All coefficients reported in the table are linear probability estimates of α_1, that is, effect of program exposure as outlined in our baseline specification. We estimate the effect of JGY exposure on four vaccines that should be administered at birth: Polio1, Hepatitis B, BCG, and DPT1 (6 weeks after birth). We report results for

[14]We have estimated the regressions using probit and results are similar. Please see online appendix for probit results.

the full sample and for boys and girls separately. We also report specifications with and without fixed effects. All regressions control for a full set of household demographic and socio-economic variables outlined in the previous section.

Our results indicate that for the full sample, if exposure to the JGY program at birth goes from 0 to 100%, the probability of receiving BCG at birth increases by approximately 2.8%, and the probability of receiving Hepatitis B vaccine increases by 18%. No effect is found on DPT1 and Polio1. When we separate the sample by child gender, we find the effect on BCG to be more significant for girls than boys. For girls, the exposure increases the probability of receiving BCG vaccine at birth by 5.6% but there is no statistically significant effect on boys. The effect on Hepatitis B vaccine is similar for both genders.

By estimating equation (2), we report the effect of first year average exposure on vaccines that should be administered by age one as recommended by IAP and MHFW. By the completion of age one, a child should receive the following vaccines: Polio3, Hepatitis B, BCG, DPT3, Measles, and Vitamin A.[15] For this analysis we only use samples greater than or equal to 12 months so that there is sufficient time for children in our sample to receive these required vaccines. Results in Table (6) indicate that for the full sample (12 months and older), a full year's exposure to the JGY increases the probability of receiving BCG vaccine by 4.7% and Polio3 by 13.4%. Or equivalently, every additional month of full program exposure would increase BCG vaccination by 0.4% and Polio3 by 1.12%.[16]

[15] Note that DPT3 can only be administered if both DPT2 and DPT1 are administered. Same for Polio3 vaccine.

[16] Note that the average first year exposure is calculated as $\frac{1}{12}\sum_{s=0}^{11} Exposure_{idt+s}$, where t is the year-month when the child was born, and $Exposure_{idt+s}$ is program exposure for month $t+s$. For example, if program exposure (percentage of villages that implemented the JGY program) in district A for year 2004 is as follows:

Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.0

A child born in district A on Jan 3rd, 2004, by our definition, would have average exposure = (0.1+0.2+0.3+0.4+0.5+0.6+0.7+0.8+0.9+1+1+1)/12 = 0.625. A direct interpretation of this number is difficult. Hence, we borrow a definition by Gentzkow and Shapiro (2008) and interpret monthly exposure as the percentage of a *full month* exposure, for example, the exposure for Jan 2004 is interpreted as the child received 10% of one full month exposure during the first month she was born. The average exposure during first year can therefore be interpreted as the percentage of a full year (12 months)

We also report the effect of first year average exposure for children aged 36 months and above only. This is the age cohort that experienced the fastest expansion of JGY and hence has the largest variation in program exposure during first year of birth. We expect JGY to have a larger impact on this cohort because there is longer time for children to receive catch-up vaccines if they missed the routine vaccines. Results for this cohort are reported in Table (7). We report results without fixed effects and with full set of fixed effects. As expected, the effect of JGY program exposure during first year is more pronounced for this age group. JGY significantly increased vaccination rate for DPT3, Polio3, and Hepatitis B. Using the interpretation outlined in footnote (16), for every one additional full month exposure to the JGY program during first year of life, the probability of receiving DPT3 vaccine increases by 3%, Polio3 by 2.8%, and Hepatitis B by 6.7%.

Overall our results suggest that JGY program exposure has a significant effect on receiving routine vaccinations on time. In particular, we find that the program has increased the probability of receiving BCG and Hepatitis B vaccines at birth and the probability of receiving BCG and Polio3 by age one. Program exposure has more significant effect on the older cohort of 36 months and above that experienced the fastest expansion and most variation in exposure.

6.3 Falsification tests

In order to test the validity of our model, we show results from falsification tests in this section. The validity of our model is based on the assumption that the full set of fixed effects is able to absorb all the unobservables that may both affect our treatment variable and the outcomes. This assumption cannot be tested directly, but we run a falsification test by replicating the estimation in equation (1) using the urban sample in the same districts of residence. Since JGY was only implemented rural Gujarat, we should expect to see no significant effect of the treatment vari-

exposure. In our case the child received 62.5% of a full year exposure during her first year of life. The coefficient for BCG (4.7%) means that if a child's full year exposure to the program increases from 0 to 100%, the vaccination rate increases by 4.7%. It is equivalent to saying that if we give the child one additional month of exposure, the vaccination rate, on average, would increase by 4.7%/12 = 0.40%. Similarly, we have the effect of one additional full month exposure on Polio3 to be 13.4%/12 = 1.12%.

able (*Exposure*) on our outcomes if our model is valid. Table (8) presents the falsification test results for all the main outcomes we have reported in section (6.2). Using the urban sample, we cannot reject the null hypothesis that the coefficients for *Exposure* are not statistically different from zero for eight out of the nine outcome variables. The only marginally significant result found is on Polio3 for children aged 36 months and above, and this result is very sensitive to control variables included in the specification.[17] Results from the falsification tests provide further support for our identification strategy and suggest that our estimation is not picking up a spurious correlation between JGY rollout and child vaccination.

7 Mechanisms

Section (4) outlined four mechanisms through which JGY plausibly affects child vaccination: income effect through increased time endowment, substitution towards more labor intensive activities, reduced time cost of healthcare facility visit due to supply side effect, and better access to health-related information. We shall examine these mechanisms in the following sub-sections.

7.1 Supply side effect

The first channel that we examine is the reduced cost of time for facility visits. In rural India, this mainly involves time spent traveling to and from the healthcare facility as well as waiting time at the facility. We argue that as quality of electricity supply improves, facilities are able to have better lighting, more advanced equipments, and larger vaccine stocks to effectively reduce waiting time and improve service quality and reliability.

To study the impact of JGY on operational efficiency and service quality of primary healthcare facilities, we use the PHC survey from DLHS-II and DLHS-III and match each facility with the rollout of the JGY program. The PHC survey is part of the facilities survey conducted by DLHS to better understand the availability of healthcare facilities and utilization. The first phase was completed in 1998-1999, where 221 districts were surveyed. In 2003, the second phase was conducted on the remaining 331 districts. In 2008, a complete survey was conducted in all districts together with the

[17] Results available in online appendix.

DLHS-III survey. We use districts surveyed in both DLHS-II and DLHS-III in our analysis. It is important to note that the timing of survey rollout for PHCs is different from household surveys. All PHC surveys in DLHS-II were completed before the rollout of the JGY program. Therefore, all facilities have zero program exposure by our definition. All PHC surveys in DLHS-III were conducted after the completion of JGY program hence all facilities surveyed in this wave have full program exposure. We cannot explore the heterogeneity in district rollout of the survey as we did using the household survey. Therefore, we use PHC surveys in the neighboring state of Maharashtra as comparison group and perform a difference-in-differences estimation using DLHS-II and DLHS-III in Gujarat and Maharashtra.[18]

With the repeated cross-section data from Gujarat and Maharashtra, we use the following specification to identify the effect of JGY on facility outcomes

$$Y_{idt} = \alpha_0 + \alpha_1 T_i + \alpha_2 P_t + \alpha_3 T_i \times P_t + D_d + \epsilon_{idt}. \tag{3}$$

Y_{idt} is a set of binary outcomes variables that indicate the availability of a number of equipments that require high quality electricity, including cold box, vaccine carrier, deep freezer, and icelined refrigerator at facility i in district d surveyed in wave t. These medical equipments serve as measures of service quality and operational efficiency at each facility. We expect facilities to own more of these equipments after being exposed to JGY. The increase in medical equipments would lead to improvement in operational efficiency and service quality as discussed in section (4). We also examine the effect of JGY on number of beds in each facility. Number of beds is used as a measure of operational capacity as it might also affect waiting time and quality of service. T_i takes value 1 if a facility is in Gujarat and 0 if it is in Maharashtra. P_t takes value 1 if a facility was surveyed in DLHS-III and 0 if it was surveyed in DLHS-II. The difference-in-differences identification assumption is that without the electrification upgradation program, Gujarat would have the same growth in operational efficiency and service quality as its neighboring state Maharashtra.

[18] Maharashtra and Gujarat are comparable states based on their socio-economic indicators. No electrification upgradation program was implemented in Maharashtra during our time of study.

Results for healthcare facility analysis are reported in Table (9). All results are estimated using linear probability model. Our results show that the JGY program has led to significant increase in availability of cold box, vaccine carrier, and deep freezer at local PHCs. If the program exposure of a facility goes from 0 to 100%, it increases the probability of having a cold box by 4.2%, vaccine carrier by 3.2%, and deep freezer by 6.8%. We also estimate equation (3) using OLS and the number of beds per facility as the outcome variable. Result in column 1 Table (9) indicates that program exposure also leads to an increase in hospital beds by 0.8 units. These results are consistent with our hypothesis that electrification upgradation increases child immunization as a result of improved operational efficiency as well as quality and reliability of service at PHCs.

7.2 Health information

The second channel we examine is whether improved quality of electricity improves access to health information. When continuous electricity supply is available households may spend more time watching television. We hypothesize that the improved electricity quality lead households to obtain more health information through these channels, including information on child vaccination. As a large share of mothers in rural India are illiterate, it is much easier and accessible for them to learn about health through television rather than newspapers or other print media. Hence, JGY would also increase the overall health knowledge received by rural households, particularly rural mothers.

In order to explore the variation in access to electricity, we adopt a similar empirical strategy as section (7.1). We use household data from Gujarat and Maharashtra for both DLHS-II and DLHS-III. As the DLHS-II household survey was conducted mid-way through the implementation of JGY, we use 12 districts with no exposure to JGY in DLHS-II and match them with the same districts in DLHS-III for Gujarat. The DLHS-II and DLHS-III surveys contain data on information on sexual and reproductive health accessed through different types of media. We use this variable as a proxy for heath information transmitted through different media. We use the full rural sample from both waves for Maharashtra. A difference-in-differences estimation is then performed using both pre- and post-JGY data for these two states.

Results are reported in Table (10). The outcome variables examined are whether a woman age 15-49 has ever heard about reproductive tract infections (RTIs) and sexually transmitted infections (STIs), including HIV and through which medium. We find that exposure to JGY increases probability of being aware about RTIs and STIs by 3.4% (column 1). Among all respondents that are aware, exposure to JGY increases the probability of learning about RTIs and STIs through television by 4.9% and reduces the probability of learning about these diseases from newspapers by 0.5%. These results are consistent with our hypothesis that the electrification upgradation program improves overall access to health information for rural women. In particular, it increases the probability of accessing health information through television.

7.3 Household time use

A third channel, as outline in section (4), is a change in time use towards different activites within the household, including labor supply. As electrification can effectively improve labor productivity, households might be able to subsitute towards more labor intensive activies. It also has an endowment effect as it would make the days longer. Unfortunately, DLHS surveys do not have time use or questions related to household labor productivity (such as different types of lighting and cooking technologies). We hence resort to descriptive statistics generated from the NSS employment data to address this potential channel.

NSS is a nationally representative household survey conducted by the Ministry of Statistics and Program Implementation (MOSPI) of the Government of India. Data have been collected on various socio-economic topics since 1950s. We construct time use data for Gujarat from the 55th, 61st, and 68th rounds of the Employment and Unemployment Schedule. The 51st round was conducted in 1999, which was five years before the JGY program was implemented, the 61st round was conducted during the program implemention in 2004, and the 68th round was conducted after the JGY implementation in 2011.

Table (11) present descriptive statistics on the proportion of time spent per week on different types of activities by women. Our data suggest that on average, women spend more time on productive activities, including participating in the labor market and engaging in domestic activites. The largest increase in time use is domestic activites, followed by wage labor. There is a significant decrease in proportion of time spent on non-productive activities as reported in the last column.

Although no clear causal inference can be drawn from these numbers, the descriptive statistics suggest that after the implementation of JGY, women are spending more time on productive activities. This alludes to a plausible endowment effect as the days become longer. We also see that they spend more time, proportionately, on domestic activities, which suggests that domestic activites are more labor intensive and benefit more from the increase in electrification quality.

Child immunization is a very labor intenstive activity, compared to other activities that can be simultaneously conducted at home. Therefore, our descriptive statistics seem to suggest that the intra-household allocation of time and increase in time endowment could also be a potential channel through which electrification improves immunization rate.

7.4 Alternative explanations

An alternative explanation for the observed improvement in child vaccination is through reduction in fertility. Previous studies have attempted to investigate the link between electrification and fertility. However, empirically, the effect of electrification on fertility is ambiguous.[19]

We use a similar specification as Burlando (2014b) and estimate the

[19]Burlando (2014b,a)finds that electricity blackout increases conception during the blackout period and leads to increased number of births ten months later. Using household-level survey data from Cote d'Ivoire, Peters and Vance (2011) find a negative relationship between electrification and fertility for rural households, but the effect was positive only for urban households. Bailey and Collins (2011) look at the United States in the period between 1920 and 1960, studying the impact of average exposure to electricity over the peak childbearing period (ages 15-29) on completed fertility. They find a negative relationship between early exposure to electricity and completed fertility, specifically, an increase in exposure from 0 to 100% could significantly reduce the total number of children ever born by 0.008. Grimm et al. (ming) provide a recent piece of evidence on the impact of television on fertility. Using a district-level difference-in-differences approach, they analyze various pathways through which access to electricity affects fertility in Indonesia. Their results suggest that increasing coverage of electricity accounts for about 18% to 24% of the overall decline in fertility. A key channel is increased exposure to television, which affects fertility preferences and increases the effective use of contraception.

exposure to the JGY on the number of children born by district. We group the number of children born in each district in each quarter and match with the average JGY exposure for that quarter. Using data from DLHS-III we estimate the regression as follows:

$$y_{dq} = \alpha_0 + \alpha_1 Exposure_{dtq} + \varphi D_d + \gamma(D_d{\cdot}t) + \phi W_q + \epsilon_{dtq}, \tag{4}$$

where outcome y_{dtq} is the number of births in district d in year-quarter q. $Exposure_{dq}$ is defined as the average percentage of villages electrified in district d and year-quarter q. We also control for district fixed effects (D_d), year-quarter fixed effects (W_q), and district-specific time trend $\gamma(D_d{\cdot}t)$ in order to account for mean differences across districts, birth year-quarter, and any district-specific trend in birth rates.

Results are reported in Table (A.2) in the online appendix. No statistically significant result was found using our specification. Hence, we do not find evidence to support reduction in fertility owing to electrification as a mechanism underlying increased child vaccination.

Another possible explanation is that improvement in electricity supply leads to construction of more PHCs and therefore increases the number of health facilities that households can access. It this is the case, the observed improvement in immunization might be a result of increased number facilities rather than servcie quality at existing facilities. To examine this, we use the information on health facility accessibility in the village survey of DLHS-II and DLHS-III and adopt a similar empirical strategy as section (7.1). We construct four variables to measure the accessibility of health facilities: whether there is a PHC in the village; the distance from the village to the nearest PHC; whether there is a SC in the village; the distance from the village to the nearest SC.[20] We include all the villages in Gujarat and Maharashtra and estimate (3). Results reported in Table (A.3) in the online appendix suggest that JGY has no significant impact on health facility accessibility. We thus do not find supporting evidence that the impact on child vaccination is due to improved access to health facilities.

[20]The distance variable takes value zero if the PHC or SC was located in the village.

8 Conclusion

This paper exploits district-level variation in the rollout of an electrification upgradation program in Gujarat, India to measure the effects of large public infrastructure on child immunization. We address the endogeneity in the rollout of the program using a fixed effects model. Our results indicate that JGY significantly increases probability of receiving Hepatitis B and BCG at birth. First year exposure to the electrification program increases the BCG and Polio3 vaccination rate. The magnitude of the effect is higher if we restrict our sample to children 36 months and older as they were exposed to fastest expansion of JGY and variation in program exposure.

Our paper is one of the very few that support supply side improvements as determinants of uptake of preventive care. In India, immunization is provided for free in government clinics and therefore in our theoretical framework we argue that the biggest cost of immunization is time. In analyzing the channels through which JGY is at work, we show that the operational capacity and efficiency at local healthcare facilities, which directly impinge on time spent on getting vaccinated, significantly improve. Further, the total time endowment to households also increases, allowing women to spend more time on domestic activities including child care. In addition, we find that electrification also increases allocative efficiency of households' health production as they receive more health information through television. We rule out reduced fertility and increased construction of health clinics due to improved electrification as alternative explanations for increased immunization rates.

This paper provides the first causal evidence on the welfare effects of improved 'quality' of electricity supply in a developing country. To our knowledge, this is also the first paper to explicitly link electrification and child health, specifically, child immunization. By studying the relationship between the unique JGY and child immunization, this paper provides further empirical support on the trickle-down effects of large infrastructure projects.

Appendix A: Data appendix on construction of immunization variables

The variables measuring whether a child received BCG, Hepatitis B, Measles, DPT1, Polio1, DPT3, and Polio3 vaccines and Vitamin A doses are constructed from information on vaccination card and mother's recall if there is no vaccination card. That is to say, the variable takes value 1 if the vaccination card indicates that the child has received the specific vaccine, or if the mother recalled that the child has received when the card is not seen, and takes value 0 otherwise. The variable takes missing value if there is no available information on the vaccination card, or the mother could not remember. The variable Polio0 measuring whether the child received the zero dose of polio vaccination within the first 2 weeks after birth is constructed as follows: first, if the vaccination card of the child is seen, the variable takes value 1 if the date of receiving Polio0 recorded on the card was within 2 weeks after birth date; second, if the card is not seen, or there is no card, then mother would recall if the child received Polio0 within 2 weeks after birth and the variable takes value 1 if mother said yes and takes value 0 if not; third, if both the date recorded on the card and mother's recall is missing, the variable takes missing value.

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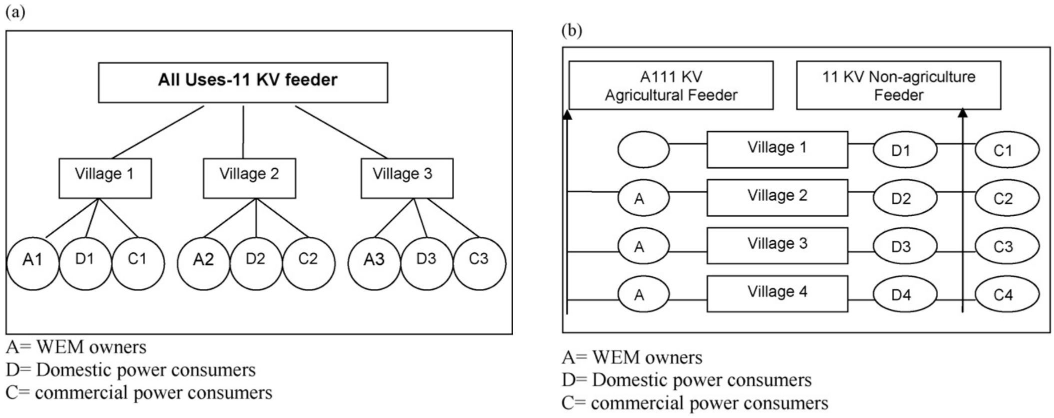
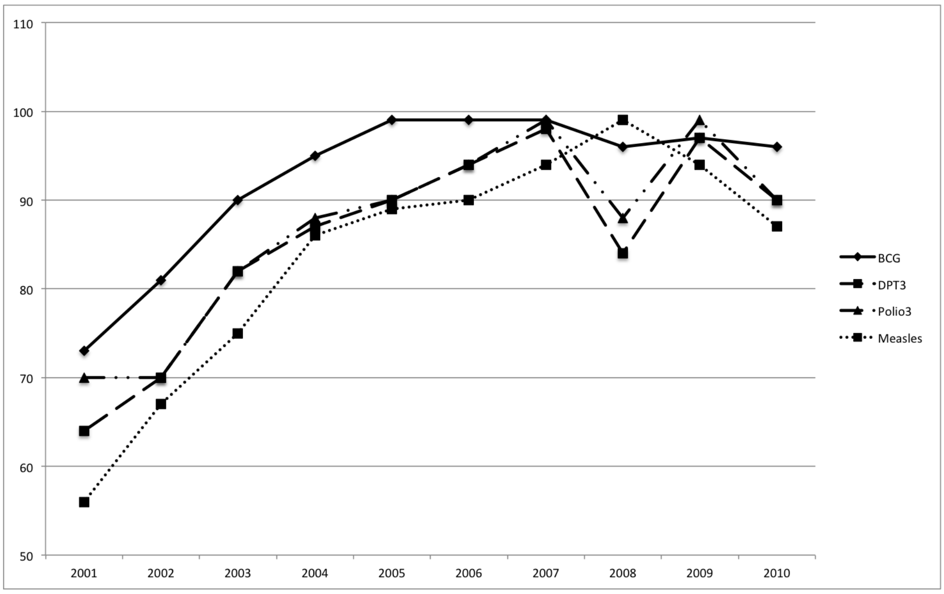


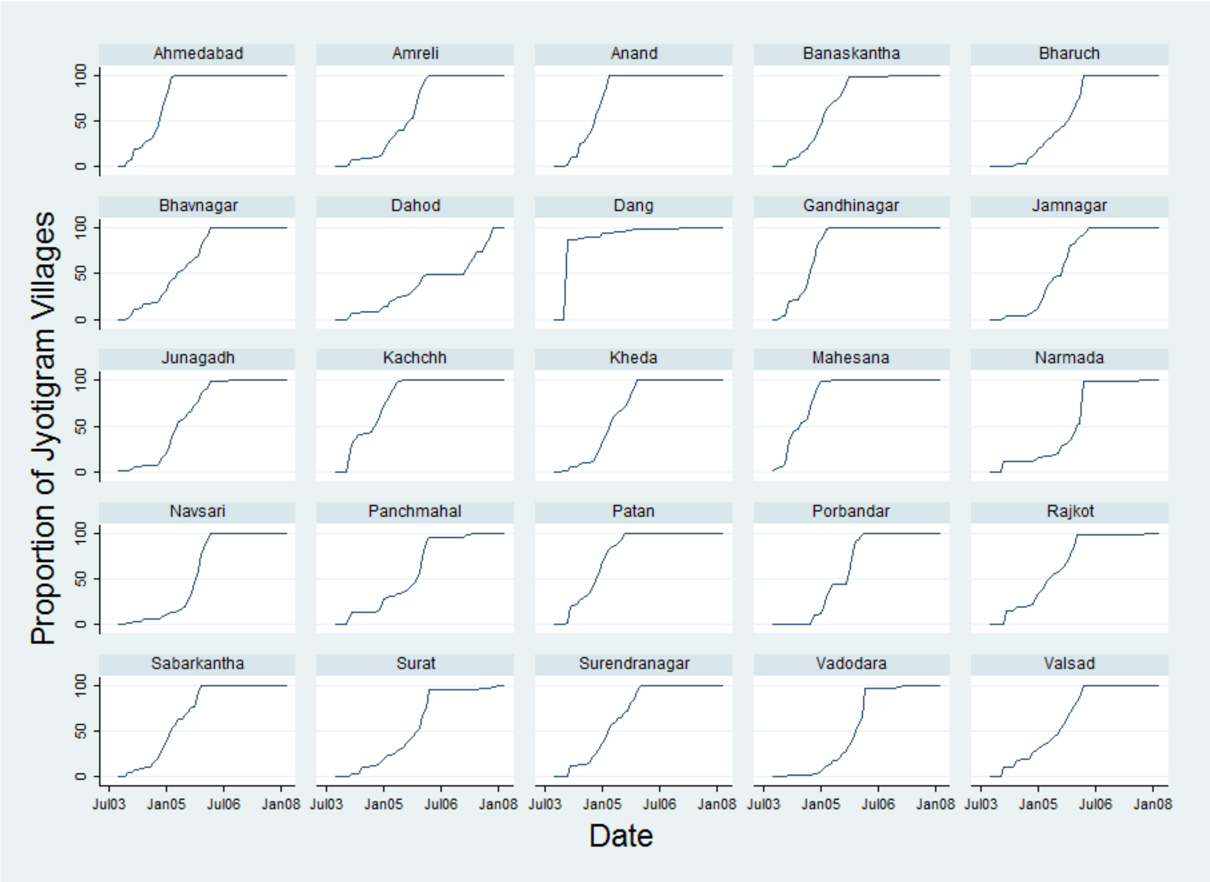
Figure 1: Pre- and post-JGY feeder system
Source: Shah et al. (2008)

Figure 2: Vaccination rates in India



Source: Immunization, Vaccines and Biologicals (IVB) database, WHO (2015)

Figure 3: JGY program rollout by district



Source: Authors' calculations using administrative data on JGY program rollout

Table 1: Why child did not receive vaccination?

	Full sample			Boys			Girls		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.
Child too young	654	0.376	0.485	347	0.340	0.474	307	0.417	0.494
Lack of information	654	0.356	0.479	347	0.363	0.482	307	0.349	0.477
Mother too busy	654	0.168	0.374	347	0.173	0.379	307	0.163	0.370
Too far to go	654	0.0948	0.293	347	0.0865	0.281	307	0.104	0.306
Time inconvenient or long waiting time	654	0.0780	0.268	347	0.0720	0.259	307	0.0847	0.279
Financial problem	654	0.0107	0.103	347	0.0144	0.119	307	0.00651	0.0806

Table 2: Vaccine schedule

Age	Routine Vaccine
At Birth	BCG, Polio0, HepatitisB-0
6 Weeks	Polio1, DPT1, HepatitisB-1
10 Weeks	Polio2, DPT2, HepatitisB-2
14 Weeks	Polio3, DPT3, HepatitsB-3
9 Months	Measles, VitaminA

Note: vaccine schedule as recommended by the Indian Academy of Pediatrics (IAP) and the Ministry of Health and Family Welfare (MHFW)

Table 3: Summary statistics of DLHS-III - outcome and program exposure variables

	0-11 months			12-23 months			24-35 months			>= 36 months		
	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D	N	Mean	S.D
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Polio1	1,449	0.882	0.323	1,698	0.975	0.155	1,668	0.971	0.167	1,804	0.982	0.134
Polio2	1,449	0.723	0.448	1,698	0.920	0.271	1,668	0.924	0.264	1,804	0.932	0.252
Polio3	1,449	0.520	0.500	1,698	0.796	0.403	1,668	0.819	0.385	1,804	0.832	0.374
DPT1	1,413	0.775	0.418	1,660	0.902	0.297	1,632	0.899	0.302	1,759	0.907	0.290
DPT2	1,413	0.603	0.489	1,660	0.816	0.388	1,632	0.824	0.381	1,759	0.841	0.365
DPT3	1,413	0.444	0.497	1,660	0.687	0.464	1,632	0.689	0.463	1,759	0.720	0.449
BCG	1,433	0.930	0.256	1,689	0.948	0.221	1,656	0.957	0.203	1,797	0.958	0.200
Measles	1,410	0.318	0.466	1,659	0.783	0.412	1,629	0.840	0.366	1,740	0.860	0.347
FirstPolio2Weeks	1,329	0.524	0.500	1,559	0.636	0.481	1,485	0.698	0.459	1,643	0.700	0.458
HepatitisB	1,649	0.128	0.334	1,595	0.340	0.474	1,518	0.392	0.488	1,707	0.421	0.494
Vitamin	1,748	0.183	0.387	1,721	0.601	0.490	1,643	0.645	0.479	1,814	0.673	0.469
Program Exposure												
Proportion of JGY villages at birth	1,820	0.993	0.0370	1,854	0.956	0.128	1,834	0.843	0.224	1,985	0.333	0.310
Average Proportion of JGY villages in the first year				1,854	0.976	0.0808	1,834	0.933	0.141	1,985	0.542	0.302

Note: Raw mean from a retrospective dataset constructed from DLHS-III, 2007-2008, based on birth history reported by ever-married women aged 15-49. Only last and second last birth born since 2004.01.01 and alive at the time of interview of each interviewed woman is included.

Table 4: Summary statistics of DLHS-III - control variables

	Full sample			Boys			Girls		
	N	mean	sd	N	mean	sd	N	mean	sd
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Proportion of JGY villages at birth	7,491	0.772	0.339	3,928	0.772	0.340	3,563	0.773	0.338
Average Proportion of JGY villages in the first year	6,735	0.840	0.268	3,550	0.841	0.266	3,185	0.838	0.270
Age in months	7,491	25.23	14.71	3,928	25.36	14.70	3,563	25.09	14.72
Birth order	7,491	2.450	1.671	3,928	2.471	1.688	3,563	2.427	1.652
Multiple birth	7,491	0.00988	0.0989	3,928	0.00866	0.0926	3,563	0.0112	0.105
Mother's age at birth	7,491	24.63	4.803	3,928	24.76	4.835	3,563	24.49	4.763
Mother's education level in years	7,491	3.698	4.302	3,928	3.688	4.322	3,563	3.709	4.280
Father's education level in years	7,491	6.438	6.684	3,928	6.422	6.868	3,563	6.456	6.476
Wealth index	7,491	-0.125	0.752	3,928	-0.119	0.754	3,563	-0.132	0.750
Household size	7,491	7.233	2.880	3,928	7.219	2.928	3,563	7.247	2.827
Age of head	7,491	43.36	13.90	3,928	43.51	14.12	3,563	43.19	13.66
Female head	7,491	0.0411	0.199	3,928	0.0418	0.200	3,563	0.0404	0.197

Note: Raw mean from a retrospective dataset constructed from DLHS-III, 2007-2008, based on birth history reported by ever-married women aged 15-49. Only last and second last birth born since 2004.01.01 and alive at the time of interview of each interviewed woman is included.

Table 5: Effect of JGY exposure at birth on vaccination status - full sample

Coefficient for *Exposure* (Program exposure at birth)	BCG			Polio1			Hepatitis B			DPT1			Polio0[a]		
Outcome Variables	(1)	(2)	(4)	(5)	(6)	(8)	(9)	(10)	(12)	(13)	(14)	(16)	(17)	(18)	(20)
Full Sample	0.010	0.019	0.028**	-0.017	0.006	-0.011	0.145	0.140	0.177**	0.010	0.052	-0.012	-0.006	-0.025	-0.012
	(0.029)	(0.028)	(0.013)	(0.019)	(0.018)	(0.016)	(0.122)	(0.126)	(0.069)	(0.056)	(0.057)	(0.030)	(0.051)	(0.053)	(0.045)
Observations	6,575	6,575	6,575	6,619	6,619	6,619	6,469	6,469	6,469	6,464	6,464	6,464	6,016	6,016	6,016
R-squared	0.033	0.043	0.064	0.059	0.123	0.134	0.116	0.127	0.163	0.100	0.146	0.167	0.441	0.448	0.460
Boys	-0.009	-0.003	0.009	-0.034**	-0.006	-0.010	0.162	0.152	0.191**	0.001	0.041	-0.036	-0.014	-0.036	-0.026
	(0.026)	(0.025)	(0.024)	(0.016)	(0.013)	(0.021)	(0.128)	(0.127)	(0.084)	(0.052)	(0.055)	(0.053)	(0.050)	(0.053)	(0.062)
Observations	3,456	3,456	3,456	3,475	3,475	3,475	3,414	3,414	3,414	3,391	3,391	3,391	3,186	3,186	3,186
R-squared	0.039	0.056	0.084	0.054	0.111	0.129	0.123	0.139	0.178	0.098	0.148	0.173	0.438	0.447	0.465
Girls	0.027	0.042	0.056***	0.002	0.020	-0.010	0.126	0.130	0.161*	0.021	0.070	0.024	0.005	-0.009	0.003
	(0.035)	(0.033)	(0.019)	(0.027)	(0.025)	(0.016)	(0.122)	(0.127)	(0.081)	(0.069)	(0.068)	(0.051)	(0.063)	(0.066)	(0.050)
Observations	3,119	3,119	3,119	3,144	3,144	3,144	3,055	3,055	3,055	3,073	3,073	3,073	2,830	2,830	2,830
R-squared	0.033	0.050	0.073	0.073	0.160	0.178	0.113	0.136	0.178	0.112	0.167	0.195	0.448	0.462	0.478
District FE	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
Cohort FE	N	N	Y	N	N	Y	N	N	Y	N	N	Y	N	N	Y
District Trend	N	N	Y	N	N	Y	N	N	Y	N	N	Y	N	N	Y
Household Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note: Above results are estimated with a retrospective dataset constructed from DLHS-III, 2007-2008. Only children in rural area are included. Robust standard errors clustered by districts are reported in parentheses. Each cell is estimated with a separate regression with linear probability model. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

[a] Due to data availability, unlike other vaccination status measures, this variable measures not whether the child received Polio0, but whether the child received Polio0 within the first two weeks after birth.

Table 6: Effect of first year JGY exposure on vaccination status - 12 months and older

Coefficient for *Exposure* (Program exposure during first year)	BCG		Measles		DPT3		Polio3		Vitamin		Hepatitis B	
Outcome Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Full Sample	0.013	0.047*	0.101	-0.009	0.007	-0.069	0.019	0.134**	0.134	-0.005	0.186	0.033
	(0.036)	(0.024)	(0.101)	(0.064)	(0.099)	(0.105)	(0.055)	(0.057)	(0.141)	(0.084)	(0.158)	(0.092)
Observations	5,142	5,142	5,028	5,028	5,051	5,051	5,170	5,170	5,178	5,178	4,820	4,820
R-squared	0.027	0.054	0.053	0.089	0.126	0.163	0.048	0.079	0.084	0.130	0.062	0.115
Boys	-0.018	0.006	0.112	0.130**	0.014	-0.023	0.001	0.115	0.139	-0.001	0.197	0.038
	(0.039)	(0.031)	(0.102)	(0.055)	(0.122)	(0.151)	(0.047)	(0.074)	(0.121)	(0.140)	(0.169)	(0.145)
Observations	2,723	2,723	2,661	2,661	2,671	2,671	2,735	2,735	2,732	2,732	2,565	2,565
R-squared	0.035	0.075	0.063	0.103	0.135	0.184	0.052	0.089	0.100	0.151	0.073	0.140
Girls	0.043	0.085**	0.088	-0.155	-0.002	-0.162	0.044	0.131	0.124	-0.010	0.174	0.075
	(0.034)	(0.037)	(0.108)	(0.127)	(0.088)	(0.103)	(0.076)	(0.103)	(0.169)	(0.193)	(0.153)	(0.161)
Observations	2,419	2,419	2,367	2,367	2,380	2,380	2,435	2,435	2,446	2,446	2,255	2,255
R-squared	0.025	0.063	0.048	0.116	0.123	0.180	0.054	0.101	0.075	0.146	0.057	0.134
District FE	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Cohort FE	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
District Trend	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Household Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note: Above results are estimated with a retrospective dataset constructed from DLHS-III, 2007-2008. Only children in rural area are included. Robust standard errors clustered by districts are reported in parentheses. Each cell is estimated with a separate regression with linear probability model. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Effect of first year JGY exposure on vaccination status - 36 months and older

Coefficient for *Exposure* (Program exposure during first year)	BCG		Measles		DPT3		Polio3		Vitamin		Hepatitis B	
Outcome Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Full Sample	-0.038*	0.090	-0.003	0.219	-0.091	0.364*	-0.010	0.336**	-0.016	-0.019	0.055	0.796**
	(0.021)	(0.086)	(0.067)	(0.212)	(0.078)	(0.201)	(0.049)	(0.138)	(0.081)	(0.238)	(0.107)	(0.368)
Observations	1,797	1,797	1,740	1,740	1,759	1,759	1,804	1,804	1,814	1,814	1,707	1,707
R-squared	0.032	0.072	0.064	0.108	0.112	0.173	0.049	0.098	0.081	0.143	0.064	0.131
Boys	-0.078***	0.101	0.036	0.455	-0.066	0.002	-0.004	0.294	0.063	0.380	0.032	1.224**
	(0.021)	(0.144)	(0.072)	(0.303)	(0.072)	(0.319)	(0.052)	(0.241)	(0.102)	(0.332)	(0.118)	(0.478)
Observations	930	930	908	908	914	914	937	937	953	953	899	899
R-squared	0.043	0.101	0.080	0.138	0.131	0.207	0.066	0.149	0.098	0.194	0.077	0.183
Girls	-0.003	0.125	-0.046	0.053	-0.113	0.642**	-0.009	0.269	-0.104	-0.257	0.061	0.486
	(0.028)	(0.105)	(0.080)	(0.286)	(0.097)	(0.303)	(0.065)	(0.203)	(0.085)	(0.390)	(0.114)	(0.382)
Observations	867	867	832	832	845	845	867	867	861	861	808	808
R-squared	0.034	0.104	0.063	0.143	0.111	0.205	0.056	0.145	0.077	0.174	0.071	0.167
District FE	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Cohort FE	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
District Trend	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Household Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note: Above results are estimated with a retrospective dataset constructed from DLHS-III, 2007-2008. Only children in rural area are included. Robust standard errors clustered by districts are reported in parentheses. Each cell is estimated with a separate regression with linear probability model. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Falsification test: Effect of JGY at birth on vaccination status using urban sample

Outcome Variables	BCG	Polio1	Hepatitis B	DPT1	Polio3	Measles	DPT3
Coefficient for *Exposure* (Program exposure at birth)	-0.022		-0.035				
	(0.033)		(0.117)				
Observations	1,989		1,937				
R-squared	0.120		0.274				
Coefficient for *Exposure* (Program exposure during first year)	-0.013				-0.100		
	(0.069)				(0.212)		
Observations	1,545				1,545		
R-squared	0.126				0.135		
Coefficient for *Exposure* (Program exposure during first year - 36 months and older)	-0.052		0.066		0.495*	-0.144	0.177
	(0.088)		(0.417)		(0.260)	(0.240)	(0.279)
Observations	571		549		572	563	568
R-squared	0.203		0.356		0.220	0.191	0.275

Note: Above results are estimated with a retrospective dataset constructed from DLHS-III, 2007-2008. Only children in urban area are included. Robust standard errors clustered by districts are reported in parentheses. Each cell is estimated with a separate regression with linear probability model. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Mechanism: Service Quality and Reliability of Health Facilities

	(1) # of beds	(2) Electricity	(3) Tap water	(4) Cold box	(5) Vaccine carrier	(6) Deep freezer	(7) Icelined refrigerator
Difference-in-differences	0.768**	0.015	-0.020	0.042**	0.032**	0.068***	0.040
	(0.349)	(0.016)	(0.049)	(0.019)	(0.014)	(0.022)	(0.026)
R-squared	0.088	0.006	0.007	0.008	0.012	0.012	0.017
Mean of outcome	6.852	0.965	0.523	0.966	0.984	0.954	0.941
Difference-in-differences with district FE	0.829**	0.015	-0.017	0.039**	0.033**	0.064***	0.034
	(0.334)	(0.016)	(0.045)	(0.019)	(0.014)	(0.022)	(0.025)
R-squared	0.171	0.038	0.158	0.037	0.060	0.056	0.072
Mean of outcome	6.852	0.965	0.523	0.966	0.984	0.954	0.941
Observations	1816	1,816	1,816	1,816	1,816	1,816	1,816

Note: Above results are estimated with facility data from DLHS-II and DLHS-III. Only health facilities located in districts that were interviewed in both waves are included. Robust standard errors are reported in parentheses. Each cell in Column (2) - Column (7) is the difference-in-differences estimator estimated with a separate regression with linear probability model. Each cell in Column (1) is the difference-in-difference estimator estimated with a separate regression with OLS model. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 10: Mechanism: Health information

	Full Rural Sample	Restricted Sample	
	Ever heard of HIV	Heard from TV	Heard from Newspaper
VARIABLES	(1)	(2)	(4)
Gujarat x Wave III	0.034***	0.049***	-0.005
	(0.009)	(0.016)	(0.015)
Observations	55,122	31,191	31,191
R-squared	0.145	0.252	0.177

Note: Above results are estimated with eligible-woman data from DLHS-II and DLHS-III. All women ages 15-49 in rural area are included. Robust standard errors are reported in parentheses. Each cell is the difference-in-differences estimator estimated with a separate regression with linear probability model. * p < 0.10, ** p < 0.05, *** p < 0.01.

Table 11: Mechanism: Household time use

NSS Round	Self-Employment	Labor Market	Domestic Work	Other Activities	Frequency
55	0.197	0.183	0.210	0.410	25709
	(0.380)	(0.372)	(0.395)	(0.485)	
61	0.218	0.186	0.209	0.388	20592
	(0.396)	(0.378)	(0.389)	(0.484)	
68	0.201	0.181	0.233	0.385	15710
	(0.392)	(0.382)	(0.415)	(0.486)	
Total	0.205	0.183	0.215	0.397	
	(0.389)	(0.377)	(0.398)	(0.485)	

Note: Figures refer to proportion of time spent per week on each activity. Self-employment refers to time spent working in household enterprise on own account or as an employer. Labor market refers to time spent on regular salaried, wage earning, or casual employment. Domestic work refers to time spent on domestic duties including any caregiving activities and free collection of goods for the household such as food, water, and fuel. Other activities refers to attending an educational institution, being a retiree or pensioner, inability to work due to disability, begging, prostitution, and being a child aged 0-4 years.

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Figure A.1: Vaccine cold chain in India

Source: Ministry of Health and Family Welfare (2010)

Table A.1: Electricity tariff structure

(a) Electricity tariff structure for agricultural users

Year	HP Based Tariff	Metered Tariff	Tatkal Scheme#
Up to 2010	For entire contracted load Rs.140/BHP/month	Fixed Charges: Rs.10 per BHP per month	Fixed Charges: Rs.10 per BHP per month
		Energy Charges: For entire consumption- 50 Paise per unit per month	Energy Charges: 70 Paise per unit per month

(b) Electricity tariff structure for residential users

Year	Consumer Category	Fixed Charges+	Energy Charges+	Special Fare for BPL**
Up to 2006-07	Residential: Rural	(a) Single Phase Rs.5.25 per month	(a) First 50 units - 220 Paise per unit	Nil
		(b) Three Phase Rs.15.75 per month	(b) Next 50 units- 250 Paise per unit	
			(c) Next 100 units - 310 Paise per unit	
			(d) Next 100 units - 360 Paise per unit	
			(e) Above 300 units- 420 Paise per unit	
2007-2010	Residential: Rural	i) Upto including 2 kW – Rs.5/ month	(a) First 50 units - 220 Paise per unit	Fixed charges Rs.5/- per month
		ii) Above 2 kW to 4 kW – Rs.15/month	(b) Next 50 units- 250 Paise per unit	Energy Charges
		iii) Above 4kW to6 kW – Rs.30/-month	(c) Next 100 units - 310 Paise per unit	(a) First 30 units 150 Paise per unit
		iv) Above 6 kW – Rs.45/month	(d) Next 100 units - 360 Paise per unit	(b) For remaining units rate as per rural residential user
			(e) Above 300 units- 420 Paise per unit	

Source: GUVNL
+ Total bill is sum of fixed and energy charges.
**The consumer who wants to avail the benefit of the below poverty line (BPL) tariff has to produce a copy of the BPL card issued by the government at the sub-division office of the distribution licensee. The concessional tariff is only for 30 units per month.

Table A.2: Alternative Explanation: Fertility rate

	All women		Age < 35	
	(1)	(2)	(3)	(4)
Average exposure in the quarter of conception	1.626	4.645	1.700	4.502
	(4.187)	(3.870)	(4.053)	(3.699)
Observations	464	464	463	463
R-squared	0.701	0.721	0.691	0.712
Mean of outcomes	16.97	16.97	16.35	16.35
District FE	Y	Y	Y	Y
Year-quarter FE	Y	Y	Y	Y
District Trend	N	Y	N	Y

Note: Above results are estimated with the birth history data from DLHS-III. All live births and still births are included. Robust standard errors clustered at district level are reported in parentheses. Each cell is estimated with a separate regression with OLS model. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.3: Alternative Explanation: Health facility accessability

	Primary Health Center		Sub-center	
	In village?	Distance	In village?	Distance
	(1)	(2)	(3)	(4)
Difference-in-differences	0.019	-0.959	0.012	-0.045
	(0.025)	(0.603)	(0.033)	(0.380)
R-squared	0.007	0.007	0.002	0.001
Mean of outcome	0.146	8.637	0.399	3.545
Difference-in-differences with district FE	0.017	-0.813	0.008	-0.004
	(0.025)	(0.586)	(0.033)	(0.368)
R-squared	0.034	0.077	0.047	0.053
Mean of outcome	0.146	8.637	0.399	3.545
Observations	3,628	3,569	3,628	3,544

Note: Above results are estimated with village data from DLHS-II and DLHS-III. Robust standard errors are reported in parentheses. Each cell is the difference-in-differences estimator estimated with a separate regression. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.